



Air Force Research Laboratory Materials & Manufacturing Directorate

Wright-Patterson Air Force Base • Dayton, Ohio

Winter 1998

National Space and Missile Materials Symposium "Space Materials & Processes for the 21st Century"

More than 300 representatives from the government, academia, and industry gathered recently at the U.S. Air Force Academy in Colorado Springs, Colorado, for the 1998 National Space and Missile Materials Symposium.

This inaugural symposium was sponsored by the Air Force Research Laboratory Materials and Manufacturing Directorate (ML), the National Aeronautics and Space Administration, the Army Research Laboratory, and the Office of Naval Research. With a theme of "Space Materials and Processes for the 21st Century," the symposium addressed the materials technologies necessary to conquer the challenges of space, launch, and missiles.

Symposium attendees were welcomed by Brig. Gen. Brian Arnold, Director of Requirements at Air Force Space Command, along with Lt. Gen. Tad Oelstrom, Superintendent of the Academy. The recently retired Commander of U.S. Space Command, Gen. Howell M. Estes, III, was the keynote speaker for the event. Other plenary session speakers included: Lt. Gen. (Ret.) Spence Armstrong, associate administrator for the Aeronautics and Space Transportation Technology and Dr. Darrell Collier, chief scientist for the U.S. Army Space and Missile Defense Command. Col. Bob Tipton, ML's Deputy Director, was a last minute stand in for Maj. Gen. Dick Paul and provided the AFRL overview.

Michael Stropki, the Directorate's Space Office Chief, and overall symposium coordinator, said many attendees felt the gathering was very worthwhile. "General Armstrong declared the symposium a success from the onset, in that we brought together all the materials people from government and industry."

The symposium was held at the Academy's Arnold Hall, at the back door of both the U.S. and Air Force Space Commands (located at nearby Peterson Air Force Base). The academic environment of cadets also provided a welcome backdrop for focusing on future materials technologies for space.

In addition to the plenary session, there were six different technical sessions and feedback from attendees concerning the forum and topics was very

enthusiastic and positive. Many people from the Directorate were involved in these sessions.

Scott Theibert co-chaired the first technical session, "Re-entry and Hypersonics," which provided an overview of a spectrum of materials that will be required for future vehicles in hypersonic flight. The second technical session, "Launch and Propulsion Systems," portrayed the essential role materials play in propulsion systems, with a focus on the materials technologies required to meet the needs of future rocket-powered vehicles. Dr. Allan Katz was one of the co-chairs of this session.

"Vehicle Structures and Cryotanks" was the title of the third session, which addressed launch vehicle structures and cryogenic tanks. Toby Cordell co-chaired the next session, "System Sustainment," which looked at the ability to ensure the prolonged fitness of space and missile systems. Bob Denison and Liz Shinn were two of the co-chairs of the "Spacecraft and Payloads" session, which discussed materials technologies that can be applied to multiple systems, both military and commercial. The final technical session, "Survivability," co-chaired by Bill Woody, considered threats to satellites and the use of materials to protect space assets.

One of the goals of the symposium's organizers was to uncover opportunities for "joint programming" or "joint partnerships" to increase technology leveraging. "We were successful at least in part in this," according to Stropki. "The Ballistic Missile Defense Office, Jet Propulsion Laboratory,

National Reconnaissance Organization, and members of industry have all asked to participate in the future." Additional organizations have sought to participate as co-sponsors for future symposiums.

Stropki noted that he received a great amount of positive feedback. "General Estes applauded us for bringing the materials community together as a forum to tackle issues of the national space program."

Stropki anticipates that the Symposium will be held about every 18 months. "I envision this as a regular national event," he concluded, "where the nation focuses on critical and hot topic material areas that will influence space infrastructures."



Materials R&D Success Stories

Filmless Radiography System For Aerospace Applications Eliminates Hazardous Waste

Under a contract with the Air Force Research Laboratory (AFRL), engineers from Liberty Technologies Incorporated have developed a digital image X-ray system for the nondestructive inspection of aerospace components which eliminates the need for radiographic film, hazardous chemicals, and associated image development equipment. The filmless radiography system will provide near real-time inspection results and could save the Air Force millions each year in hazardous waste disposal costs.

A steadily decreasing budget has caused the Air Force to delay procurement of new weapon systems, and extended the service life of current weapon systems. To meet increasing requirements for sustaining an aging aircraft fleet, accurate, efficient and cost-effective methods are necessary for detecting service and corrosion damage.

X-ray radiography, frequently used by the Air Force to seek out these problems and assess the quality of in-service weapon system parts and assemblies, requires the use of X-ray film, associated processing chemicals, and film processing equipment. The Air Force spends several million dollars annually for industrial X-ray film alone, plus more to cover the cost of processors, processing chemicals, and silver recovery units necessary to recover environmentally hazardous by-products of the film development process. Additionally, significant man-hours must be expended to continuously maintain and manage film processing and archiving.

Engineers from Liberty Technologies Incorporated, working under contract with the AFRL Materials and Manufacturing Directorate, adapted their RADView® nondestructive evaluation system of filmless radiography to the Air Force environment to provide a system suitable for weapon system inspections. Their objective was to produce an X-ray system which could eliminate or significantly reduce the use of radiographic film, chemicals and ancillary equipment required in the process of developing, viewing, and storing radiographic images of aerospace structures. Their work, resulted in a digital process using a phosphor imaging plate and laser scanning technology to produce high precision digitized images. The digital data is imaged in video format where it can be viewed

on a high resolution monitor, archived on an optical disk, or converted to a hard copy. Imaging plates can be erased and reused, eliminating the application and disposal costs associated with consumable film. The prototype filmless radiography system was modified to incorporate Air Force requirements for aircraft inspection, image storage, and X-ray procedure modification.

The project developed both characteristic and exposure curves for X-ray energies in the 50kv to 160kv range and revealed the potential associated with slightly longer exposures at reduced photomultiplier tube voltages. It also demonstrated the beneficial use of various filters at the tube head. Field tests were conducted at a number of depots and operational field environments. While the primary evaluation emphasis was on the F-15 fighter, some work was also accomplished relative to the inspection needs of the C-141 transport and T-38 trainer aircraft.

The application of a filmless radiography system for nondestructive evaluation of aircraft at air logistics centers and field units will significantly reduce operating costs by lowering or eliminating the use and handling of hazardous materials and disposal costs associated with conventional X-ray radiography systems.

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@ml.wpafb.af.mil or (937) 255-6469. Refer to item 98-248.



Filmless radiography system in use.

Low Cost Composite Processing Methods May Revolutionize Prototype Manufacturing

Scientists and engineers at the Air Force Research Laboratory (AFRL) Materials and Manufacturing Directorate have developed composite parts processing methods that may reshape the way military and commercial prototypes are built in the future.

These "Low Cost Composite Processing" (LCCP) methods use lightweight aerospace composite materials based on resins that can be cured at temperatures much lower than those used for conventional composite materials. The result is a major reduction in the cost of applying organic matrix composites to aerospace structures by eliminating the requirement to process parts in autoclaves.

Current market demands for developing new vehicles in less time and at less cost, combined with an emphasis on increased performance and quality standards for prototype vehicles, has created major challenges for designers, engineers and prototype manufacturers. This has caused a trend towards reducing the costs of parts manufacturing, even during low-volume production, while producing components of technically superior quality. This trend is especially noticeable in the composites manufacturing sector, where non-recurring costs such as design and production of prototypes can be quite high, especially for low production volumes. As a result, conventional approaches to prototyping are being replaced with the emerging rapid prototyping technologies, as well as with the production of cost-effective, fully working "real" prototype systems which can be used as technology demonstrators.

For many working prototypes and technology demonstrators, composite materials are required to obtain the desired performance goals, yet cost and time constraints limit the use of traditional autoclave processed composite materials. Autoclave processing typically utilizes high temperatures and pressures and requires



Applications in space and automotive technology

expensive and long lead time autoclave hardened tooling. LCCP methods produce composite parts without the use of an autoclave.

In a collaborative effort with defense and aerospace companies, researchers at the AFRL Materials and Manufacturing Directorate helped develop advanced structural composite materials designed to be processed at temperatures as low as 60°C, as opposed to traditional materials processed at 177°C, thereby eliminating the requirement for autoclave processing and associated expensive tooling. Their work with Boeing St. Louis under the LCCP program enabled a 40 percent reduction in fabrication cost for a composite aircraft wing using non-autoclave processing versus conventional processing.

LCCP methods are being used today by the automotive industry to design and build race cars and also by Lockheed Martin's "Darkstar" unmanned battlefield surveillance vehicle program. Expanded research in non-autoclave processing technologies could lead to the successful production of large, complex one-piece composite structures but without the size, thermal constraints and tooling costs associated with autoclaves.

A primary LCCP component, the "Low Temperature Moulding" (LTM™) pre-impregnation composite material system currently being advanced by the Advanced Composites Group, enables the exploitation of composite performance in programs that cannot afford conventional composite materials with their associated autoclave processing costs.

Continuing research in these areas could lead to more cost-effective prototyping and also save millions of dollars by making low-volume production more affordable.

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@ml.wpafb.af.mil or (937) 255-6469. Refer to item 98-203.

Compact Generator May Improve Air Force "Bare Base" Operations

Engineers at the Air Force Research Laboratory (AFRL), working with private industry, have designed a revolutionary compact power generator which can rapidly deploy to remote, austere air fields to support Air Expeditionary Force (AEF) operations. The generator offers greatly improved reliability, better fuel economy, and reduced logistics and operations and maintenance costs over power generation systems currently in use.

When the AEF must rapidly deploy to "bare base" operating locations, logistics are critical to the success of the mission. One crucial element is airlift; moving cargo quickly to where it needs to go. Important factors such as volume and weight greatly impact a deployment operation.

The "bare base" power generator systems the Air Force currently uses are large and heavy, were built based on 1960's technology, and account for greater than five percent of the initial and follow-on deployment sorties. Rapid deployment of AEF necessitates the development of compact, lightweight equipment.

Research engineers at AFRL's Materials and Manufacturing Directorate Airbase and Environmental Technology Division, at Tyndall AFB, Fla., collaborated with private industry to design a compact, lightweight power generator that is more reliable, saves fuel, and costs less to operate and maintain. The new design concept is based on a high-speed rotary engine as a prime mover, a permanent magnet disk generator for power generation, and state-of-the-art electronic switching devices for power conditioning. The rotary engine was selected for its compact size, light weight and high performance characteristics. Rotary engines also offer a multi-fuel capability for JP-4, JP-5, JP-8, diesel, gasoline and kerosene.

When combined with its rectifier and inverter, the magnet disk generator is capable of producing electric power of 50/60/400 hertz frequency without the loss of output power. The control architecture is designed to respond to transient loads without decreasing in-line voltage or frequency and also to reduce fuel consumption and engine wear through variable speed operation. A 120 kilowatt set was recently tested by at Tyndall AFB and initial test results were extremely favorable.

The weight of the new generator set is approximately 40 percent less than conventional generator sets, and this, combined with the compact design, less engine wear as a result of the variable speed operation and rotary engine technology, could revolutionize power generation systems and greatly benefit U.S. military rapid deployment operations. Continuing research into rotary engine-powered generator systems could lead to more efficient systems in the military and commercial industry.



Current power generators

For more information, contact the Materials and Manufacturing Directorate's Technology Information Center at techinfo@ml.wpafb.af.mil or (937) 255-6469. Refer to item 98-222.

CALENDAR OF EVENTS

Polymers/Organics for Mems
January 28, WPAFB, OH

April 15, Dayton, OH
May 20, Dayton, OH

AeroMat '99
June 21-24, Dayton, OH

High Temple Workshop XIX
February 1-4, Denver, CO

**Materials, Manufacturing and
Enabling Technologies Series**
February 25, Dayton, OH
March 18, Dayton, OH

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CONTRACTS

COMPLETED

- Optical Radars - F33615-91-C-5619
- Manufacturing Technology Special Advanced Studies - F33615-92-D-5812
- Alternate Nositip Concepts - F33615-92-C-5965
- Ultra-Thin Cast Nickel-Base Alloy Structures - F33615-93-C-4305
- Metal Forming Simulation - F33615-93-C-5318
- Precision Thick Film Technology For 100% Yield - F33615-94-C-4406
- Improved Emissive Coatings for Super High Efficiency Color AC-PDPs - F33615-94-C-4408
- Minnesota Consortium for Defense Conversion - F33615-94-2-4417
- Manufacturing 2005: The Textile/Apparel Initiative - F33615-94-C-4430
- Low Cost Flat Panel Display Fabrication - F33615-94-1-4448
- High Mobility Silicon Carbide Substrates - F33615-94-C-5411
- Infrared Countermeasure Materials: Quasi-Phase-Matched Crystal Plate - F33615-94-C-5416
- Laser/Materials Interaction Studies for Enhanced Sensitivity - F33615-95-C-5223
- Improved Materials for Electro-Optic and Nonlinear Optic Applications in Mid-Infrared - F33615-95-C-5435
- Permanent Dry Film Resist for Printed Wiring Board Process Simplification and Environmental Benefit - F33615-95-C-5504
- Activity-Based Costing for Agile Manufacturing - F33615-95-C-5516
- Neural Network Error Compensation of Machine Tools - F33615-95-C-5541
- Modeling for Sensor-Based Semiconductor Process Control - F33615-95-C-5543
- Gradient Morphology Hybrid Resins for Rigid-Flexible Printed Wiring Board Adhesives - F33615-95-C-5622
- Metal Forming Tool Design - F33615-96-C-5107
- Enhanced Laser Generated Ultrasound - F33615-96-C-5268
- Resin Transfer Molding of High Temperature Composites - F33615-97-C-5018
- Layered Silicate/Organic Polymer Nanocomposite Materials - F33615-97-C-5097
- Performance Evaluation of Improved Lubricants for Tribological Systems - F33615-97-C-5099
- Affordable Tooling for Composite Structures - F33615-97-C-5142
- Advanced Casting Technology for Low Cost Composites - F33615-97-C-5143
- Developing a Flexible Mandrel and Semi-Flexible Tooling for the Fabrication of Integrated Composite Structures - F33615-97-C-5152
- Terahertz Optical Modulator - F33615-97-C-5495

NEW

- Rugate Thermal Control Coatings - F33615-98-C-5046
- Composite Preburner and Turbopump Housing Materials and Process - F33615-98-C-5051
- Tribological Properties of Quasicrystals - F33615-98-C-5056
- An Adaptable Environment For Parts Obsolescence Management. - F33615-98-2-5148
- Conformable Multichip Assembly Technology - F33615-98-C-5149
- Systems Engineering Using Key Characteristics - F33615-98-C-5158
- Simulation-Based Design System For Multi-Stage Manufacturing Processes - F33615-98-C-5163
- Turbine Engine Applications of Ceramic Composites - F33615-98-C-5216
- Research on Advanced Nondestructive Evaluation Methods - F33615-98-C-5217
- Mixed Anion Heterostructure Materials - F33615-98-C-5428
- High-Q Tunable Capacitors and Multi-Way Switches Using MEMS - F33615-98-C-5429
- Terahertz Optical Modulator - F33615-98-C-5430
- Silicon Carbide Semiconductor Substrates - II - F33615-98-2-5433
- Design and Improve Synthesis of Carbon Nanotube Materials - F33615-98-C-5435
- Production of Semiconductor Grade Crystals From Recovered Manufacturing Waste - F33615-98-C-5439



**Air Force
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